ANNOTATED LIST OF THE PERONOSPORALES OF OHIO

(I. ALBUGINACEAE AND PERONOSPORACEAE)[1, 2]

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ABSTRACT

The known Ohio species of the Albuginaceae and of the Peronosporaceae, and of the host species on which they have been collected are listed. Five species of *Albugo* on 35 hosts are recorded from Ohio. Nine of the hosts are first reports from the state. Thirty-four species of Peronosporaceae are recorded on 100 hosts. The species in this family reported from Ohio for the first time are: *Basidiophora entospora, Peronospora calotheca, P. grisea, P. lamii, P. rubi, Plasmopara viburni, Pseudoperonospora humuli,* and *Sclerospora macrospora.* New Ohio hosts reported for this family are 42.

The Peronosporales are an order of fungi containing the families Albuginaceae, Peronosporaceae, and Pythiaceae, which represent the highest development of the class Oomycetes (Alexopoulous, 1962). The family Albuginaceae consists of the single genus, *Albugo*. There are seven genera in the Peronosporaceae and four commonly recognized genera of Pythiaceae. Most of the species of the Pythiaceae are aquatic or soil-inhabitants, and are either saprophytes or facultative parasites. Their occurrence and distribution in Ohio will be reported in another paper.

The Albuginaceae include fungi which are all obligate parasites of vascular plants, causing diseases known as white blisters or white rusts. These white blisters are due to the development of numerous conidia, sometimes called sporangia, in chains under the epidermis of the host. None of the five Ohio species of *Albugo* cause serious diseases of cultivated plants in the state. White rust of spinach (Wiant *et al.*, 1939) caused by *Albugo occidentalis* and white rust of horse-radish (Endo and Linn, 1960) caused by *A. cruciferarum* are sometimes destructive elsewhere in the United States. *Albugo cruciferarum* is found on many species of Cruciferae and is known to be composed of a number of physiologic races differing in ability to parasitize the various crucifers (Alexopoulos, 1962). In Ohio it rarely occurs on the cultivated crucifers, but is common on weedy species, such as shepherd's-purse (*Capsella bursa-pastoris*). Other plants in Ohio commonly affected with species of *Albugo* include *Amaranthus retroflexus, Ipomoea hederacea,* and *Portulaca oleracea.*

The species of the Peronosporaceae are obligate parasites causing the diseases known as the downy mildews. Several species of the family cause diseases of economic significance. Downy mildew fungi in Ohio which sometimes cause important diseases include *Plasmopara viticola* on grape (*Vitis labruscana*) (fig. 1), *Bremia lactucae* on lettuce (*Lactuca sativa*), *Peronospora tabacina* on tobacco (*Nicotiana tabacum*), *P. destructor* on onion (*Allium cepa*), *P. trifoliorum* on alfalfa (*Medicago sativa*), *P. manshurica* on soybean (*Glycine max*), and *Pseudoperonospora cubensis* on cucumber (*Cucumis sativus*). Some downy mildew fungi locally common on non-cultivated plants in Ohio in recent years include *Peronospora corydalis* on species of *Dicentra* (fig. 2), *P. parasitica* on *Dentaria laciniata* and on species of *Cardamine* (fig. 3), *P. polygoni* on species of *Polygonum, Plasmopara obducens* on species of *Impatiens*, and *P. geranii* on *Geranium maculatum.*

This paper includes the first Ohio report of downy mildew on wheat (*Triticum aestivum*) (fig. 4) caused by *Sclerospora macrospora.* In 1968 downy mildew (crazy top) on corn (*Zea mays*) caused by the same *Sclerospora* species was observed and reported from several localities in Ohio where corn fields had become flooded,

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following excessive rains early in the season. Waterlogging of the soil is a primary factor favoring the development of this fungus and of the disease.

A list of Ohio plants by Kellerman and Werner (1893) included four species of *Albugo* on seven hosts and five species of the Peronosporaceae on seven hosts. Stevens (1896a, 1896b, 1897, 1898) listed three species of *Albugo* on six hosts and 11 species of Peronosporaceae on 15 hosts. Brian (1912) reported two species of *Albugo* on eight hosts and five species of Peronosporaceae on six hosts. Summarized, these early workers reported four species of *Albugo* on 14 hosts and 15 species of Peronosporaceae on 23 hosts. Additional reports of Ohio Peronosporales, especially those causing diseases of cultivated plants, have been published from time to time. Ellett (1957), in a summary of Ohio parasitic fungi, reported

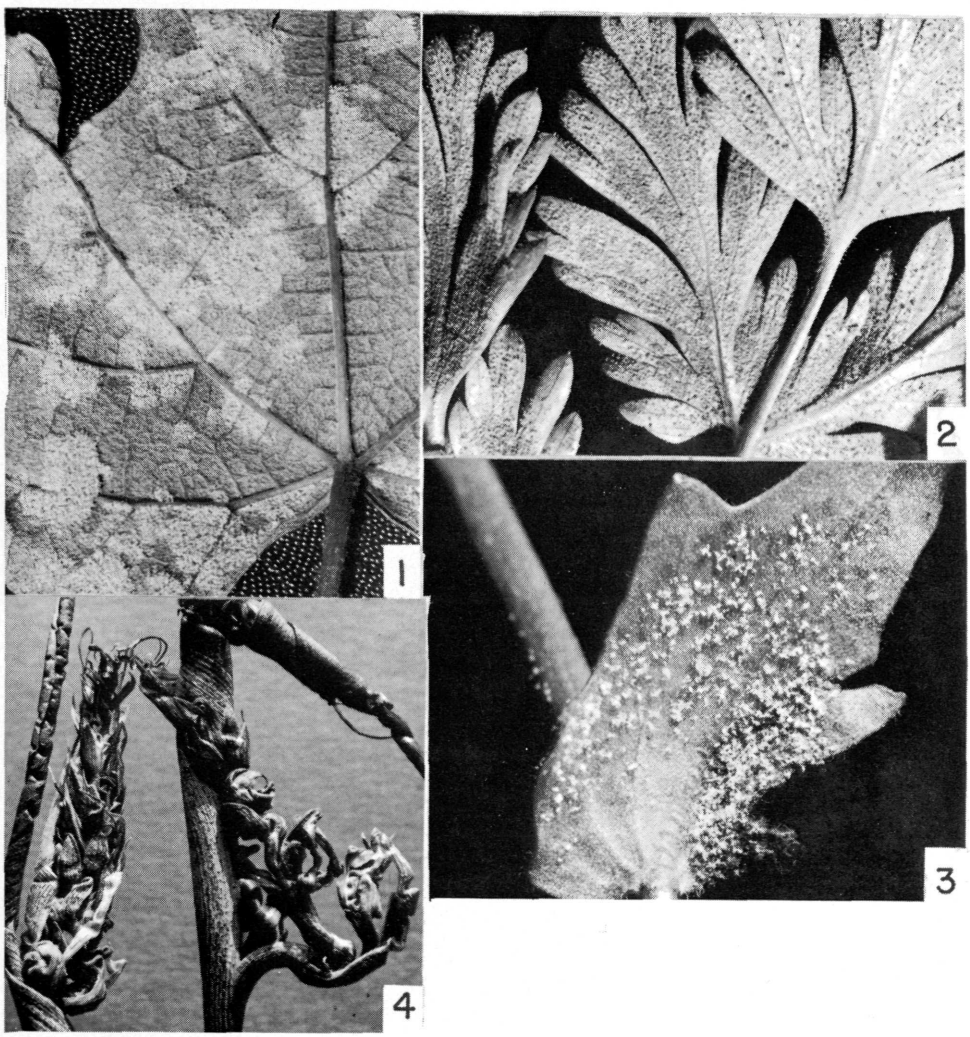

FIGURE 1. *Plasmopara viticola* on *Vitis labruscana*.
FIGURE 2. *Peronospora corydalis* on *Dicentra*.
FIGURE 3. *Peronospora parasitica* on *Cardamine*.
FIGURE 4. Downy mildew of wheat caused by *Sclerospora macrospora*.

five species of *Albugo* and 26 species of Peronosporaceae known in the state. Neither a list of the species nor their hosts was included.

The annotated list in this paper includes the known Ohio species of Peronosporaceae and Albuginaceae and their hosts. Five species of *Albugo* on 35 hosts are reported from Ohio. Nine of the hosts are first reports from Ohio. Thirty-four species of Peronosporaceae are recorded on 100 hosts. Eight of the species have not been reported before from Ohio, and new host reports number 42. Five species of *Albugo* on 36 hosts are reported in Wisconsin (Greene, 1965) and four species on 23 hosts in Minnesota (Preston and Dosdall, 1955). Sixty-two species of Peronosporaceae on 182 hosts are reported in Wisconsin (Greene, 1965), 31 species on 67 hosts in Minnesota (Preston and Dosdall, 1955), 39 species on 109 hosts in Washington, and 33 species on 80 hosts in Oregon (Shaw, 1955).

In the list which follows, the concept of a species in the downy mildew fungi as discussed by Yerkes and Shaw (1959) has been followed. These authors present convincing evidence for accepting the classification followed by most American workers rather than that of Gäumann (1923). Recent annotated lists of the Peronosporales in Norway by Jörstad (1964) and by Ramsfjell (1960) also follow the more conservative treatment rather than the extreme "splitting" of species as practiced by Gäumann and some other authors.

The list of fungi and hosts in this paper is based on herbarium collections and published reports. The majority of the collections are in The Ohio State University fungus collections. Collections of Ohio Peronosporales in herbaria of Oberlin College (OC), Miami University (MU), University of Cincinnati (CINC), and the National Fungus Collections (Beltsville) (BPI) were also examined. When specimens in these herbaria were from counties not represented by the OSU fungus collections, they were included in this index. In a few cases where a listing is based on a published report and not substantiated by a collection, the appropriate citation is included.

Most of the new Ohio records are based on collections by the author and are in The Ohio State University fungus collections. Many of the host-fungus associations reported here probably occur in every Ohio county in which the host is found. There has been no attempt to collect specimens from each county, a procedure of which I question the value. Undoubtedly, new species of Peronosporaceae for Ohio will be found, especially species of *Peronospora*. A few new Ohio host and county records have been found by checking plants in The Ohio State University vascular plant herbarium. These are indicated by listing the herbarium accession number after the county. An asterisk before a fungus or host name denotes the first Ohio report of the species or of the species on the host.

OHIO ALBUGINACEAE AND THEIR HOSTS WITH OCCURRENCE BY COUNTY

Albugo bliti (Biv.-Bern.) Kuntze. This species occurs on several genera and species of Amaranthaceae, but is known in Ohio only on *Amaranthus* species.

**Amaranthus albus* L. Franklin, Hamilton.
A. hybridus L. Hamilton (CINC), Harrison, Marion, Mercer.
A. retroflexus L. Auglaize, Belmont, Erie, Franklin, Huron, Highland, Lucas, Madison, Ottawa, Richland, Shelby, Wayne. Probably throughout Ohio.
**A. spinosus* L. Brown (18099).

Albugo cruciferarum S. F. Gray (*A. candida* (Pers. ex Fr.) Kuntze). This species is parasitic on many crucifers throughout the world. Biga (1955) distinguishes two varieties, and numerous physiologic races have been demonstrated (Baker, 1955).

**Arabis glabra* (L.) Bernh. Champaign (46106).
Arabis sp. Morrow.
Armoracia lapathifolia Gilib. Darke, Franklin, Licking, Lorain, Sandusky, Summit, Wayne.
Brassica kaber (DC.) L. C. Wheeler. Franklin, Knox.
B. nigra (L.) Koch. Athens, Franklin, Hamilton, Ottawa.
B. oleracea L. (cabbage). Reported from Ohio (U. S. Department of Agriculture, 1960).
**Cakile edentula* (Bigel.) Hook. Erie.
Camelina microcarpa Andrz. Champaign (13332).
C. sativa (L.) Crantz. Franklin.
Capsella bursa-pastoria (L.) Medic. Fairfield, Franklin, Hamilton, Hancock, Licking, Lorain (OC), Mahoning, Marion, Morrow, Ottawa, Putnam, Richland, Wayne. Probably throughout Ohio.
**Cardamine bulbosa* (Schreb.) BSP. Hocking.
Dentaria diphylla Michx. Erie (OC), Hocking, Summit.
**D. heterophylla* Nutt. Hocking.
D. laciniata Muhl. Franklin, Hamilton (CINC).
Descurainia pinnata (Walt.) Britt. Erie (Brian, 1912).
**Erysimum repandum* L. Van Wert (74134), Wood (64747).
Iodanthus pinnatifidus (Michx.) Steud. Franklin, Hamilton.
Lepidium capestre (L.) R. Br. Franklin, Highland, Seneca. Erie (Brian, 1912).
L. virginicum L. Hamilton. Erie (Brian, 1912).
Raphanus sativus L. Butler, Franklin (BPI), Putnam.
Rorippa islandica (Oeder) Borbas. Erie, Richland (13534).
**Sisymbrium altissimum* L. Ottawa (71283).
S. officinale (L.) Scop. Fairfield, Franklin, Hamilton (CINC), Lorain (OC). Erie (Brian, 1912).

Albugo ipomoeae-panduratae (Schw.) Swing. On species in the Convolvulaceae. Biga (1955) describes two varieties.

Convolvulus sepium L. Pickaway.
Convolvulus sp. Fayette, Franklin, Jackson, Pickaway, Ross.
Ipomoea hederacea (L.) Jacq. Athens, Franklin, Highland, Meigs, Muskingum, Ross, Scioto.
**I. lacunosa* L. Jackson (29421).
I. pandurata (L.) G. F. W. Mey. Hamilton.

Albugo quadrata (Wallr.) S. D. Baker (*A. portulacae* (DC.) Kuntze).

Portulaca oleracea L. Fairfield, Franklin, Hamilton (CINC), Lake, Lorain (OC), Lucas, Van Wert (BPI), Wayne. Probably throughout Ohio.

Albugo tragopogonis Pers. (S. F. Gray). This species on various of the Compositae has been divided into 5 varieties by Biga (1955).

Ambrosia artemisiifolia L. Franklin.
Antennaria plantaginifolia (L.) Hook. Hamilton.
Cirsium muticum Michx. Lucas (BPI).
Tragopogon porrifolius L. Ashtabula, Butler, Franklin, Mahoning, Wayne. Salsify is very susceptible to *Albugo;* however, there is little or no commercial production of the crop in *Ohio.*

OHIO PERONOSPORACEAE AND THEIR HOSTS WITH OCCURRENCE BY COUNTY

**Basidiophora entospora* Roze & Cornu. The conidiophore is unbranched and has a club-shaped apex covered with short sterigmata bearing the conidia.

**Aster novae-angliae* L. Pike.
**A. prenanthoides* Muhl. Hocking.
**Erigeron annuus* L. Delaware, Franklin. *Plasmopara halstedii* also occurs on this host.

Bremia lactucae Regel. The conidiophore is dichotomously branched at acute angles with the tips of the branches enlarged into discs. The conidia are borne on sterigmata arising from the disc margin. The species occurs only on Compositae, and physiologic specialization has been demonstrated with forms and races being described (Ling and Tai, 1945).

**Lactuca biennis* (Moench.) Fern. Coshocton, Fairfield, Highland, Pike.
**L. canadensis* L. Meigs.
L. sativa L. Franklin, Hamilton.

Peronospora alta Fckl. The conidiophores of *Peronospora* species are dichotomously branched, usually at acute angles, with the ultimate tips of the branches acute.

**Plantago lanceolata* L. Wood. There is only one earlier report on this host in the United States (Wilson, 1908).
P. major L. Franklin, Shelby.
P. rugelii Dcne. Lucas, Mahoning.

Peronospora arthurii Farl.

Oenothera biennis L. Coshocton, Franklin, Hardin, Lorain OC, Perry, Washington.

**Pernonospora calotheca* de Bary

**Galium aparine* L. Delaware.

Peronospora corydalis de Bary.

Cordyalis sempervirens (L.) Pers. Franklin.
**Dicentra canadensis* (Goldie) Walp. Fairfield, Franklin. Commonly systemic in this and the following species.
**D. cucullaria* (L.) Bernh. Franklin, Wood.

Peronospora destructor (Berk.) Fr.

Allium cepa L. (Van Pelt, 1919). Frequently observed in muck crop areas of north-central Ohio.

Peronospora farinosa (Fr.) Fr.

Chenopodium album L. Coshocton, Delaware, Franklin, Geauga, Lorain (OC), Ross, Wayne.
Spinacia oleracea L. Franklin. Occasional on spinach in Ohio, although there is only one herbarium collection.

Peronospora ficariae Tul.

**Ranunculus abortivus* L. Fairfield, Franklin.
**R. recurvatus* Poir. Hocking, Seneca.
**R. septentrionalis* Poir. Franklin.

Peronospora floerkeae Kell. This species was described by Prof. W. A. Kellerman (1904) from a collection near Columbus in 1902.

Floerkea proserpinacoides Willd. Franklin.

**Peronospora grisea* (Ung.) Ung.

**Veronica arvensis* L. Franklin.

Peronospora hydrophylli Waite

Hydrophyllum macrophyllum Nutt. Franklin.
H. virginianum L. Franklin.

**Peronospora lamii* A. Braun

**Lamium* sp. Pickaway.
**Lamium amplexicaule* L. Franklin.

Peronospora manshurica (Naum.) Syd. apud Gäum.

Glycine max (L.) Merr. Common in Ohio on cultivated soybean, probably in every county. Found on leaves, pods, and seeds.

Peronospora parasitica (Pers. ex Fr.) Fr. This species causes downy mildew of many of the Cruciferae. Gäuman (1923) split *P. parasitica* into more than 50 species, but Yerkes and Shaw (1959) have clearly shown the desirability of recognizing but one species.

**Arabis canadensis* L. Fairfield (14134).
**A. laevigata* (Muhl.) Poir. Columbiana (75665).
**A. perstellata* E. L. Br. Darke (55278), Putnam (55763).
**Barbarea vulgaris* R. Br. Franklin.
**Brassica nigra* (L.) Koch. Franklin, Lorain (OC).
B. oleracea L. (cabbage). Lucas, Montgomery (BPI). Prevalent in 1969 in north-central and northwestern Ohio on kraut cabbage and on cabbage for fresh market.
**B. rapa* L. (turnip). Franklin.
Capsella bursa-pastoris (L.) Medic. Franklin, Hancock, Wayne.
**Cardamine bulbosa* (Schreb.) BSP. Champaign.
**C. douglassii* (Torr.) Britt. Franklin.
C. pennsylvanica Muhl. Coshocton, Franklin, Hamilton (CINC), Hocking.
**Dentaria heterophylla* Nutt. Hocking.
D. laciniata Muhl. Champaign, Franklin, Greene, Hamilton, Muskingum, Wayne.
**Hesperis matronalis* L. Delaware, Franklin, Wayne (87818).
Iodanthus pinnatifidus (Michx.) Steud. Ross (Stevens, 1896).
Lepidium virginicum L. Erie, Franklin.
**Raphanus raphanistrum* L. Geauga.
R. sativus L. Reported from Ohio (Selby, 1910).

Peronospora polygoni Thuem. ex Fischer

Polygonum convolvulus L. Wayne.
P. cristatum Engelm. & Gray. Ohio report (U. S. Department Agriculture, 1960).
P. scandens L. Ashtabula, Coshocton, Hocking, Wayne.

Peronospora potentillae de Bary. Only previous record of this species from Ohio is by Stevens (1897) on *Potentilla* sp.

**Geum canadense* Jacq. Coshocton, Knox.
**G. chiloense* Balbis. Richland (from a graden planting). Only previous United States report is from California (U. S. Department Agriculture, 1960).
**Potentilla norvegicae* L. Franklin, Pike, Washington.

**Peronospora rubi* Rab. ex Schroet.

**Rubus* sp. Muskingum.

Peronospora sordida Berk. & Br.

Scrophularia marilandica L. Erie, Franklin, Wayne.

Peronospora sparsa Berk.

Rosa sp. Hamilton (CINC), (BPI). This 1905 collection is the only record from Ohio. Downy mildew of rose is easily overlooked. Outbreaks of rose downy mildew in the United States are discussed by Baker (1953).

Peronospora tabacina Adam

Nicotiana tabacum L. Brown, Darke. In tobacco-seed beds in southern and southwestern Ohio. The idease is often called blue mold.

Peronospora trifoliorum de Bary

Medicago sativa L. Franklin, Morrow, Ross, Scioto, Shelby, Wayne. Probably throughout Ohio on alfalfa.

Peronospora viciae (Berk.) Casp.

Pisum sativum L. Linford (1929).

Plasmopara australis (Speg.) Swing. In the genus *Plasmopara*, the conidiophore is branched at right angles and the branches and their subdivisions are irregularly spaced.

Echinocystis lobata (Michx.) T. & G Wayne (BPI).
Sicyos angulatus L. Athens, Erie, Fairfield, Wayne (CINC).

Plasmopara geranii (Pk.) Berl. & de Toni

**Geranium carolinianum* L. Licking. Appears to be systemic in this host.
G. maculatum L. Franklin, Huron, Licking, Muskingum, Pike, Vinton, Wayne. Erie (Brian, 1912).

Plasmopara halstedii (Farl.) Berl. & de Toni. Novotelnova (1962) has described 10 species and 12 form species from *P. halstedii*.

**Ambrosia artemisiifolia* L. Franklin.
**A. trifida* L. Franklin, Hocking, Knox.
Bidens frondosa L. Delaware, Franklin.
Erechtites hieracifolia (L.) Raf. Franklin.
Erigeron annuus (L.) Pers. Wayne. *Basidiophora* also occurs on this host in Ohio.
**Eupatorium* sp. Portage.
Helianthus annuus L. Franklin, Hardin, Summit.
**H. decapetalus* L. Hocking.
**H. petiolaris* Nutt. Hardin.
**H. tuberosus* L. Franklin.
Rudbeckia laciniata L. Delaware, Franklin, Hocking, Lucas.

Plasmopara obducens (Schroet.) Schroet.

Impatiens sp. Fairfield, Franklin, Hocking, Knox, Licking, Muskingum, Pike, Portage.
**I. pallida* Nutt. Hamilton, Hocking.

Plasmopara pygmaea (Ung.) Schroet.

Anemone canadensis L. Franklin.
*A. *quinquefolia* L. Wood.

**Plasmopara viburni* Peck

**Viburnum acerifolium* L. Fairfield.

Plasmopara viticola (Berk. & Curt.) Berl. & de Toni

Parthenocissus quinquefolia (L.) Planch. Franklin.
Vitis aestivalis Michx. Geauga. Erie on *V. bicolor*=? *V. aestivalis* (Brian, 1912).
V. labruscana Bailey. On cultivated grapes throughout Ohio. When conditions are favorable, the leaves are killed and the fruit is rotted, unless fungicides are used. Known in Ohio for more than 100 years (Mosher, 1857).
V. riparia Michx. Erie, Wayne.
V. vulpina L. Hamilton, Ottawa.

Pseudoperonospora cubensis (Berk. & Curt.) Rostow. *Pseudoperonospora* is similar to *Peronospora* but the conidia germinate by zoospores. The conidiophores and condidia are usually violet-tinged in mass. Most of the hosts reported below are based on collections and a study by Selby (1899).

Bryonopsis laciniosa Naud. Wayne.
Citrullus vulgaris Schrad. Wayne.
Coccinia cordifolia Cogn. Wayne.
Cucumis anguria L. Wayne.
C. melo L. Coshocton (CINC), Wayne.
C. sativus L. Cuyahoga, Franklin, Hamilton, Summit, Trumbull (CINC), Wayne. First reported in Ohio in 1895, and soon became very destructive to cucumber (Selby, 1897).
Cucurbita pepo L. Wayne.
Echinocystis lobata (Michx.) T. & G. Wayne.
Lagenaria siceraria Standl. Wayne.

Luffa acutangula Roxb. Wayne.
Melothria scabra Naud. Wayne.
Momordica balsamina L. (Selby, 1899).
M. charantia L. Selby (1899).
Sechium edule Sw. Wayne.
Sicyos angulatus L. Selby (1899).
Trichosanthes anguina L. Wayne.

**Pseudoperonospora humuli* (Miy. & Tak.) G. W. Wilson

**Humulus* sp. Crawford.

Sclerospora graminicola (Sacc.) Schroet. In the genus *Sclerospora*, the conidiophore and its numerous branches are much thickened and fugacious. All species of *Sclerospora* are on Gramineae.

Setaria viridis (L.) Beauv. Erie, Franklin, Pickaway, Sandusky, Seneca, Wood, Wyandot. Before 1967 known only from an earlier Franklin County collection. During the summer of 1967, I found this species on *Setaria* in the additional counties. The conidiophores deliquesce soon after forming, so collections must be made early in the morning.

**Sclerospora macrospora* Sacc.

**Triticum aestivum* L. Wood. The only Ohio report is this 1967 collection.
**Zea mays* L. Observed and reported from several Ohio counties in 1968 by B. F. Janson (Extension Plant Pathologist). The development of conidia of *S. macrospora* on corn or wheat is rare, but the large oospores (45–60 μ) may be found within the tissues. This downy mildew causes a twisting of the leaves, bending of the stems, and other distortions of host-plant parts. The floral parts may be converted into a leafy and branched structure. The pathogen is placed in the genus *Sclerophthora* by some (Ullstrup and Sun, 1969).

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